Project B-209

# THE FEASIBILITY OF ESTABLISHING FINGER-JOINTING OPERATIONS IN GEORGIA

Prepared for

The Georgia Department of Industry and Trade
100 State Capitol
Atlanta, Georgia

by

Tze I. Chiang

Industrial Development Division
Engineering Experiment Station
GEORGIA INSTITUTE OF TECHNOLOGY
September 1964

Table of Contents

## Summary

The process of joining wood pieces longitudinally by the use of fingered end joints has been recognized as a profitable way for salvaging waste and upgrading lumber by many woodworking concerns in recent years. Finger-jointed stock can be made to customer specifications so that a minimum waste of material on the part of users results.

The typical uses of finger-jointed stock are interior trim, door and window jambs, casing, molding, core stock, flooring, dimension stock, and underlayment. Although finger-jointed stock has not been accepted for some uses to the extent that clear lumber has, the advantage of being able to obtain specified lengths by accepting jointed lumber is overcoming much resistance.

Strength properties, appearance, and dimensional stability are the major technical factors in designing a finger-jointing process. If finger-jointed stocks are properly made, they have moderate tensile strength, high bending strength, and compression strength equal to or greater than that of solid wood. The development of overlaid lumber in recent years should increase the acceptance of finger-jointed stock for use in exposed areas. Applications which require great dimensional stability are particularly suitable for finger-jointed stock.

The major factors to be considered in determining the feasibility of setting up a finger-jointing operation are raw material availability, the use or market for the final product, and the profitability of the operation. The first and third depend largely upon the nature and volume of wood waste which a firm has. Outlets for finger-jointed stock depend upon end uses. In those fields where finger-jointed stocks are widely accepted, the real consideration lies in the margin between input value and output value.

Finger jointing is a common practice in most parts of the country. In only a few states, including Georgia, is it almost unknown. A finger-jointing operation is particularly suitable for a Georgia woodworking operation because of the shortage of high-grade lumber, the lack of adequate outlets for wood waste, the high cost of woodworking, and the keen competition from out-of-state suppliers.

Two hypothetical examples of finger-jointing operations in Georgia show (1) a profit potential of $50 dollars per day and an equipment payout period of two years for a finger-jointing operation to salvage wood waste in a prefabricated house and mobile home plant and (2) a profit potential of $175 per day and an equipment payout period of 1.6 years for an operation utilizing a high-volume finger-joint unit to upgrade southern lumber to customer specifications.

# INTRODUCTION

Finger-jointing is a process for joining wood pieces longitudinally by the use of fingered end joints. A finger joint is a series of fingers machined on the ends of two pieces to be joined which intermesh and are held firmly in position by a water-resistant adhesive. Finger joints are generally superior to other types of end joints. Butt joints are limited in use because of lack of strength. Scarf joints are the strongest of the end joints, but a considerable amount of wood is wasted in their production. Finger joints can almost duplicate the strength properties of scarf joints and can be produced at a lower cost.

In the last decade, many woodworking concerns have recognized the finger-jointing process as a profitable way of salvaging waste and upgrading lumber. Although hundreds of finger-joint machines have been installed throughout the nation, only one small unit is known to be in use in Georgia. This report is intended to introduce the finger-jointing process in terms of economics, technology, and equipment requirements to the woodworking concerns in the state.

The over-all development of the process, including the advantages, uses, technology, and equipment sources, is given first. Economic considerations follow. Finally, the opportunities for the use of the finger-jointing process in Georgia are described, and two hypothetical examples are given which illustrate specific applications of the process for Georgia.

Finger-joint manufacture quite frequently is carried on in conjunction with edge jointing. The purpose of the former is to make wood pieces longer, while that of the latter is to make pieces wider. Since edge-joint manufacture has a longer history and is widely accepted today, this report is limited to the potentials of the finger-jointing process in Georgia.

This study is a companion to the report on overlaid lumber published in May 1964 for the Georgia Department of Industry and Trade. Both finger-jointing and overlaying are methods of upgrading lumber, and the two methods can be used together.

## THE CURRENT STATE OF FINGER-JOINT DEVELOPMENT IN THE UNITED STATES

### Advantages of Finger Jointing

Upgrading Lumber. Because of exhaustive exploitation for generations, high-quality timber is becoming scarce, with the result that lumber produced today contains a greater percentage of low grades, short lengths, and narrow widths than that produced in the past. While timber in high grades and medium to long lengths is readily marketed, it is difficult to sell low grades, narrow widths, and short lengths. These low-quality materials either are discarded as a loss or sold at a low price. Disposal of these materials is a serious problem for many woodworking concerns.

Through finger jointing and edge gluing, lumber producers can upgrade their material by cutting out defects and gluing the lumber together to give a homogeneous appearance. The problem of short lengths and narrow widths also can be remedied through the use of finger and edge joints. Laminating 1 x 4's to make 2 x 4's is a current application.

Salvaging Wood Wastes. Wood residues, such as edgings, trims, short ends, and blocks, are expensive waste to many woodworking concerns because of the lack of adequate outlets for such materials. There are reports that many woodworking concerns in Georgia have to pay for disposal of their waste material.

Through the use of finger and edge joints, panel stocks and underlayment materials can be made of these wood residues. The successful use of finger-joint and edge-joint manufacture to salvage wood wastes and to increase lumber yield is a new development in recent years.

Meeting Customer Specifications. Lumber is generally purchased in random lengths and widths; buyers have to accept a certain amount of undesired lengths or widths which they do not generally need. Even at a premium price, a large quantity of lumber of specified lengths and widths may not always be obtainable. Thus, buyers of lumber have to absorb some waste in their purchasing.

Through the combination of finger jointing and edge gluing, lumber can be produced in lengths and widths specified by the customer. This results in no waste of the material purchased and a reduction in the labor required for reworking the material.

## Uses of Finger-Jointed Stocks

A survey of woodworking concerns indicates that lumber mills, millwork plants, mobile home and prefabricated home manufacturers, molding works, truck body plants, flooring companies, and furniture factories are the major types of manufacturers who use finger-jointing operations as a part of their business. It is expected that the use of finger joints will continue to increase in other types of wood manufacturing as a result of competition.

Some typical uses of finger-jointed stocks are listed below:

- Interior trim
- Door and window jambs
- Casing
- Drawer stock
- Exterior siding
- Garage doors
- Hardwood and softwood flooring
- 2 x 6 car lining
- 1 x 4 stock laminated into 2 x 4's
- 2 x 4 dimension stock
- Molding
- Door and window frames
- Core stock
- Interior paneling
- Railway car lining
- Skirt board
- Stair rails
- Table and chair legs
- 1 x 4 and 1 x 6 stock for shelving material

Although finger-jointed stock has not been accepted to the extent that clear lumber has, the advantage of being able to obtain specified lengths by accepting jointed lumber is overcoming much resistance. Furthermore, finger-jointed material is reported to be readily accepted for use on hidden components such as drawer stock, core stock, and underlayment.

The Southern Pine Association and the Western Douglas Fir Association have adopted a plan of certification for finger-jointed studs. Some millwork associations have accepted the use of finger-jointed material and have adopted commercial standards. From all indications, acceptance of finger-joint manufacture is increasing among woodworking societies.

## Technology of the Finger-Joint Process

Properties of Finger-Jointed Stock. The most critical properties of finger-jointed stock in terms of possible end uses and market acceptance are those relating to strength, appearance, and dimensional stability.

If finger-jointed stocks are properly made, they have moderate tensile strength, high bending strength, and compression strength equal to or greater than that of solid wood. Different end products require different strength properties. Such products as trim, molding, and jambs do not require high structural strength. On the other hand, stair railing materials need the

maximum strength that a finger joint can attain. Other products require specific strength properties only. Beam members need bending strength, for example, while stud members require compression strength.

The appearance of finger-jointed stock is a significant acceptance factor. Generally finger-jointed stock is readily accepted for uses in hidden parts. If it is used in paneling, paint is generally applied to cover the joint. However, the development of overlaid lumber in recent years should increase the acceptance of finger-jointed stock for use in exposed areas, since the overlay material will completely hide the joint.[1/]

Finger-jointed stock has greater dimensional stability than solid wood, since the continuous grain of clear stock is more susceptible to warping than is the broken grain of jointed stock. Applications which require great dimensional stability, therefore, are particularly suitable for finger-jointed stock.

Design of Finger Joints. In the design of finger joints, the most important consideration is the strength of the joint. In 1953, Auburn University developed an improved finger-joint design with an average bending strength of 70% to 80% of clear wood, average stress of 11,300 pounds per square inch, and average modulus of rupture of 14,210 psi.[2/] In 1957, the Timber Engineering Company reported that southern pine could reach 84% efficiency of clear wood in bending tests and 113% efficiency of clear wood in compression tests. The strength properties of jointed southern pine exceeded those of jointed ponderosa pine and redwood in both bending and compression tests.[3/]

Processing Procedure. Several major steps are involved in the finger-jointing process, each of which requires particular care to assure uniform results:

1. Preparing raw material: The material must be dried to a range of 6% to 11% uniform moisture content. The width and thickness of the material

---

1/ See Overlaid Lumber: A Manufacturing Opportunity in Georgia, by Tze I. Chiang, Industrial Development Division, Engineering Experiment Station, Georgia Institute of Technology, Atlanta, Georgia, May 1964.

2/ D. B. Richards, End Joints for Southern Pine, Agricultural Experiment Station of the Alabama Polytechnic Institute, Institute Leaflet No. 39, 1953.

3/ N. G. Hundley and J. T. Clarke, Evaluation of End and Edge Gluing Process, Timber Engineering Company, Washington, D. C., 1957.

also must be uniform. Defects, such as knots and pitch, generally are cut out before the end-joint operation is started.

2. Machining the finger joint: The joint must be cut smoothly and accurately according to the design. It must be tightly fit so that it will be self-locking. The finger-jointed stock must not be damaged or burned.

3. Glue selection and application: Selecting the proper glue mix is very important for a successful operation. The type of glue used depends upon the end product, the wood species used, and the type of machine installed. The glue applicator should be designed to spread an adequate amount of glue without excessive waste.

4. Assembly and conditioning: The major function of an assembly machine is to assemble joints tightly. The quality of the finished product is determined largely by the tightness of fit of the finger joint. After the assembly of the finger-jointed stock, the glue line is cured either at room temperature or by electrical heating.

Major Manufacturers of Finger-Jointing Equipment

Only a few companies in this country offer complete units of equipment for finger-jointing operations. Information regarding type of machinery, cost, production capacity, and requirements can be obtained directly from the following major companies:

Mann-Russell Electronics, Inc.
1401 Thorne Road
Tacoma 2, Washington

Onsrud Machine Works, Inc.
7720 North Lehigh Avenue
Niles 48, Illinois

Randall Fenton and Company
1500 South Center Street
Tulsa, Oklahoma

Stetson-Ross Machine Co., Inc.
3200 First Avenue, South
Seattle 4, Washington

Tri-State Machinery Company
2231 Valdina Street
Dallas, Texas

Each of the above companies, except Mann-Russell Electronics, Inc., offers one or more models for the complete finger-jointing operation. The costs range from $15,000 to $18,000 a set, f.o.b. mill. Although Mann-Russell Electronics does not offer a complete set of equipment, it does provide several major machines used in finger jointing.

Several machine makers have provided vast sums for engineering research in order to improve operations and to bring out new models. Impressive improvements in machinery have been made in the last few years.

## ECONOMIC CONSIDERATIONS IN ESTABLISHING A FINGER-JOINTING OPERATION

Generally, three major factors should be considered in determining the feasibility of setting up a finger-jointing (and perhaps an edge-gluing) operation:

1. raw material availability,
2. the use or market for the final product, and
3. the potential profitability of the operation.

The first two, of course, have a considerable effect on the third. A reliable profit estimate is possible only after a detailed input-output analysis has been made, based on known or anticipated values for a number of input and output variables. The output value of finger-jointed stock, for example, is affected by such variables as the dimension of stock (width, thickness, and average lengths of shorts to be processed), adhesive used, wood species, design of finger joints, and type of machine used.

Following a consideration of raw material availability and the use or market for the final product, the discussion below illustrates the profit potential of a finger-jointing operation by pointing out the major production cost considerations and describing the operating results of two existing finger-joint operations.

### Raw Material Availability

Since most existing finger-joint processes are integrated parts of other woodworking operations, the need for such a setup depends largely upon the nature and volume of wood residue or low-grade lumber which a firm has and the desire (or necessity) for better utilization of the material involved. If a firm has enough material which has little value for other uses, it would be economically advantageous to investigate the potential of the material for finger-jointing operations and the markets for finger-jointed stocks.

### The Use or Market for the Final Product

Wood waste is more useful in a furnace and less costly thrown in a scrap pile if no use or market exists for the finger-jointed product. Before buying an installation, therefore, the markets or uses must be determined. In plants where lumber is used to make a salable product, the short lengths can usually be joined for use in the same product without reducing product quality. On

the other hand, there may be resistance to accepting finger-jointed lumber on the basis that it is a cheap substitute for clear lumber.

The outlets for finger-jointed stocks vary according to end products, such as interior trim and molding, window casing, jambs and frames of windows and doors, and core stock. As for structural purposes and paneling, intensified research and promotion are needed, especially in the South. In those fields where finger-jointed stocks are widely accepted, the real consideration lies in the margin between input value and output value. Generally, the application of finger-jointing operations is more profitable on high-grade materials than on those of low grade.

## Production Costs

The total production cost of a finger-jointing operation may vary from $50 to over $200 per thousand board feet of output. This total cost is affected by many variables, including production volume (which will affect overhead and depreciation costs per unit of output), raw material cost, adhesive cost, labor rates, and the dimensions of materials to be finger-jointed. Some of the major cost considerations are material costs, utility costs, labor and overhead costs, and depreciation.

Material Costs. Several conditions affect the costs of material input, including the manner of bookkeeping utilized, glue cost, and length of material. If material waste is 50% in a woodworking concern and 25 inches is the minimum length of primary products, then material under 25 inches entering finger-jointing operations may be considered as waste with no value. On the other hand, if the setup of a finger-jointing operation is intended to increase yield of lumber from 50% to 65% for a given mill, then the material used for finger joints will be considered as cost.

Adhesive cost depends upon length of material, length and number of joints, type of spread, and type of glue used. The length of material entering the finger-jointing operation will affect yield in output and glue cost. Generally, longer material increases yield and lowers glue cost in the operation.

Utility Costs. Electric power is the major utility cost in a finger-jointing operation. The horsepower ratings of electrical equipment, operating hours, and a factor of 1.34 horsepower hours per hour can be used to estimate

daily kilowatt-hour requirements. Generally, power costs represent only a small portion of the total cost.

Labor and Overhead Costs. Labor costs can be derived from the number of operators, operating hours, wage rates, and the output volume of the machines. Overhead costs include supervision, payroll overhead, taxes, insurance, maintenance, and supplies. An overhead of 100% of direct labor, excluding stock preparation, is commonly recommended.

Depreciation. In estimating depreciation, a period of 10 years is generally used for equipment and installation. This assumes that the finger-jointing operation is an integral part of a woodworking concern and that a building exists.

## Case Reports

The operating results of two existing companies illustrate empirically the savings which are possible from finger-jointing operations. The following case reports are summarized from trade publications.

### Case A: Millwork Plant[1/]

A millwork plant which uses finger jointing for upgrading lower grades of pine reports that the average value of the lumber salvaged is about $75 per thousand board feet. At a cost of $50 it is put back into production by finger jointing, and its value is increased to about $175 per thousand. With an average daily production of between 1,000 and 2,000 board feet, depending upon widths, the average savings are estimated to be more than $50 per day.

### Case B: Wadsworth (Ohio) Millwork Corporation[2/]

Materials used are 4 x 4, 5 x 4, or 8 x 4 pine or redwood in 2" or 3" widths. Machine output per 8-hour day is 4,880 lineal feet or 1,522 board feet. Output value is $149.15 per day, based on a market price of $98 per

---

1/ The Wood-Worker, April 1959.

2/ Wood and Wood Products, December 1958.

thousand board feet. Daily operating costs are $52.30, based on the following cost items:

| | |
|---|---|
| Labor (two men at $2.50 per hour each) | $40.00 |
| Power (17 h.p. x 8 hours x 0.746 x $0.025) | 2.50 |
| Glue (2 lbs. per hour at 30¢ per lb.) | 4.80 |
| Maintenance (centerhead, saw, miscellaneous) | 5.00 |
| Daily operating costs | $52.30 |

Net savings per day are $72.64. This is based on the output value per day ($149.15) less daily operating costs ($52.30) and a 25% adjustment factor for set-up down time ($24.21). Wood cost was not included because all short material entering the production was considered as waste. The machinery cost for the finger-jointing operation was given at $13,500.

## THE POTENTIAL FOR FINGER-JOINTING OPERATIONS IN GEORGIA

### Finger-Jointing Opportunities in Georgia

Finger jointing may be profitable for a Georgia woodworking operation in one or any combination of the following ways:

1. upgrading lumber,
2. utilizing waste, or
3. meeting customer specifications as to length and width.

While these are merely restatements of the general advantages of finger jointing, they are particularly applicable in relation to the needs and opportunities of the woodworking industry in Georgia.

In Georgia there is a shortage of high-quality lumber, especially in longer lengths, whereas Douglas fir is often shipped in the longest lengths, even though such lengths are not specified. Finger jointing offers the opportunity to compete with West Coast lumber by joining shorter lengths to make long lengths. At the same time knots and other flaws can be cut out of the lumber before making the joints.

By the same means, long or wide lumber can be built up from pieces that would otherwise be considered useful only for the chipper or the boiler furnace. Many wood operations in Georgia are at present in need of some means of reducing scrap loss. Finger jointing will make it possible to step up considerably the value of the waste.

There are requirements in Georgia today for 40-foot by 1-foot hardwood boards which are presently being shipped from Memphis, Tennessee. This is an example of customer specifications which could hardly be met by any means other than finger jointing and edge gluing.

In many situations an individual company might have enough waste to justify a finger-jointing installation of its own. In other cases opportunities might exist for service operations -- installations to upgrade the waste of a number of small companies on a fee basis.

In any case, finger jointing is a common practice in most parts of the country. In only a few states, including Georgia, is it almost unknown. There are many opportunities in the fields of furniture, doors and windows, prefabricated and mobile homes, dimension stock, panels, and molding.

## Hypothetical Examples of Finger-Jointing Operations for Georgia

Two hypothetical examples are given in order to show the potential profitability of finger-jointing operations under given Georgia conditions. One is for wood-waste utilization, and the other is for upgrading lumber.

### Example A: Salvaging Wood Waste in a Prefabricated House and Mobile Home Plant

| | |
|---|---|
| Materials: | 2 x 4 or 1 x 4 short ends with lengths from 1 to 3 feet, dry condition, and at $20 per thousand board feet. The processing loss is assumed to be approximately 13%. |
| Equipment: | A low-volume finger-joint unit with speed up to 6,000 linear feet per 8 hours and valued at $25,000 with transportation cost included |
| Operating conditions: | 8 hours a day, 250 days a year, with output of 4,000 board feet a day |
| Labor: | 3 men at $1.75 per hour |
| Operating supplies: | 100% of direct labor |
| Overhead: | 100% of direct labor |
| Depreciation: | 10 years |
| Product value: | $85 per thousand board feet for 2 x 4, No. 2 yellow pine with length under 16 feet |
| Taxes: | Federal at 50% of profit and State at 5% |

Profit and costs for an 8-hour operation:

| | | |
|---|---|---|
| Gross sales (4 x $85) | | $340 |
| Production cost: | | |
| Wood material (4.6 x $20) | $92 | |
| Labor (3 x $1.75 x 8) | 42 | |
| Supplies (power, glue, maintenance, etc.) | 42 | |
| Overhead | 42 | |
| Depreciation | 10 | |
| Total production cost | | 228 |
| Profit before taxes | | $112 |
| Taxes | | 62 |
| Net profit | | $ 50 |
| Payout period | | 2 years |

Example B: Upgrading Southern Lumber

| | |
|---|---|
| Materials: | 2 x 4 or 1 x 4 low-grade lumber with defects. No. 3 or utility grade yellow pine, 2 x 4, at $50 per thousand board feet. Defects are cut out and finger-jointed to a specific length requested by customer. The processing loss is assumed to be 50%. |
| Equipment: | A high-volume finger-joint unit with speed up to 30,000 linear feet per 8 hours and valued at $70,000 with transportation cost included |
| Operating conditions: | 8 hours a day, 250 days a year, with output of 25,000 board feet a day |
| Labor: | 4 men at $1.75 per hour |
| Operating supplies: | 150% of direct labor |
| Overhead: | 120% of direct labor |
| Depreciation: | 10 years |
| Product value: | D grade yellow pine, 2 x 4, at $125 per thousand board feet with length over 20 feet |
| Taxes: | Federal at 50% of profit and State at 5% |

Profit and costs for an 8-hour operation:

| | | |
|---|---|---|
| Gross sales (25 x $125) | | $3,125 |
| Production cost: | | |
| Wood material (50 x $50) | $2,500 | |
| Labor (4 x $1.75 x 8) | 56 | |
| Supplies (power, glue, maintenance, etc.) | 84 | |
| Overhead | 67 | |
| Depreciation | 28 | |
| Total production cost | | 2,735 |
| Profit before taxes | | $ 390 |
| Taxes | | 215 |
| Net profit | | $ 175 |
| Payout period | | 1.6 years |

The two examples shown above are assumed to operate only one shift per day. The examples also assume that the wood raw material used has some cost. Actually, for many companies such cost will merely be an accounting convenience. At present, the material may have fuel value only or, in many instances, no value at all. The difference between the actual value and the value used in the examples is additional profit. These models can be adapted for woodworking concerns in the state which have the desire to utilize their wood waste.